NASA Ames Approach for Conducting DAG-TM Integrated Air-Ground Simulations

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Outline

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- New situations/problems in 2003-4
- Basic DAG scenario
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- DAG scenario, Controller's POV
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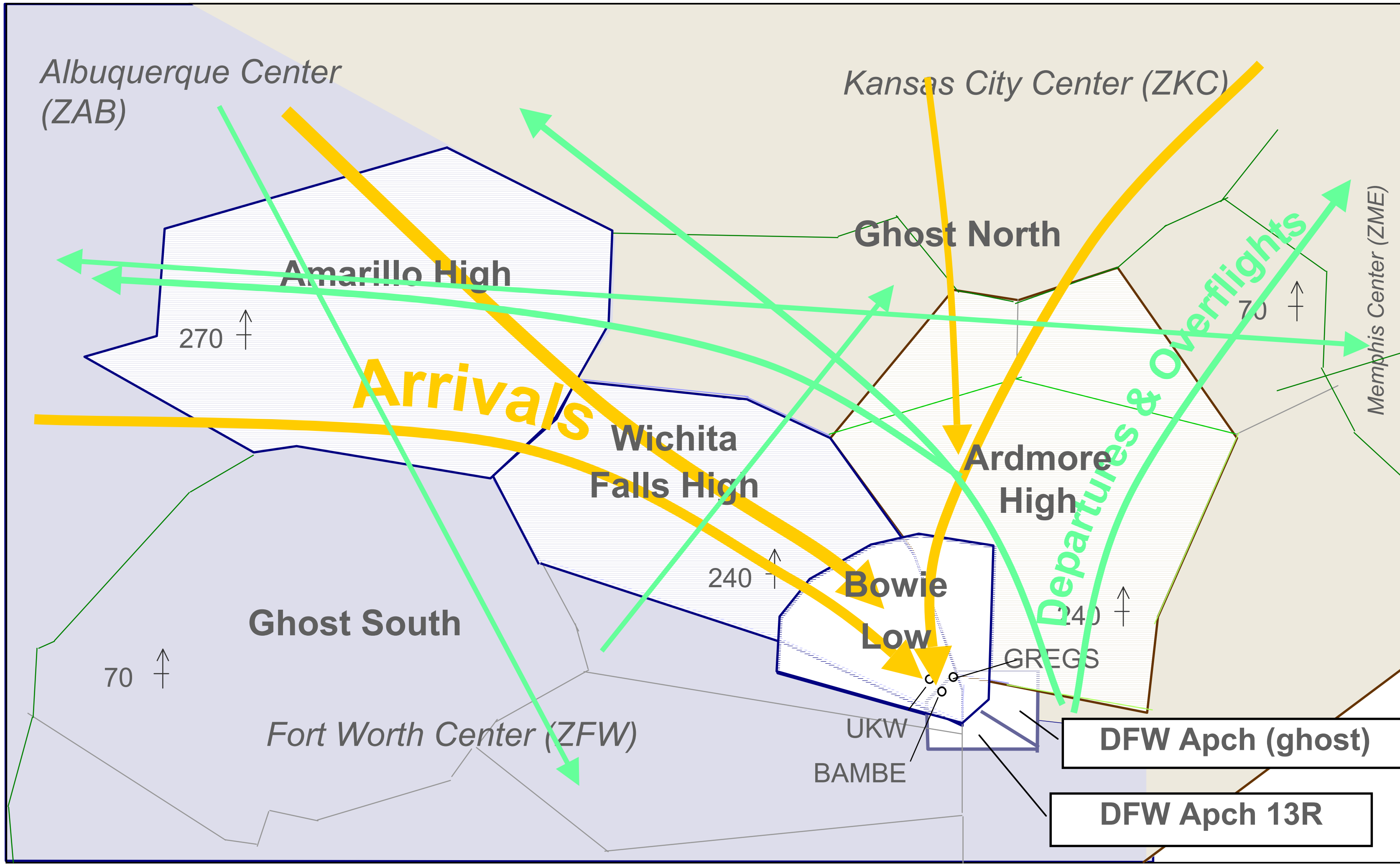
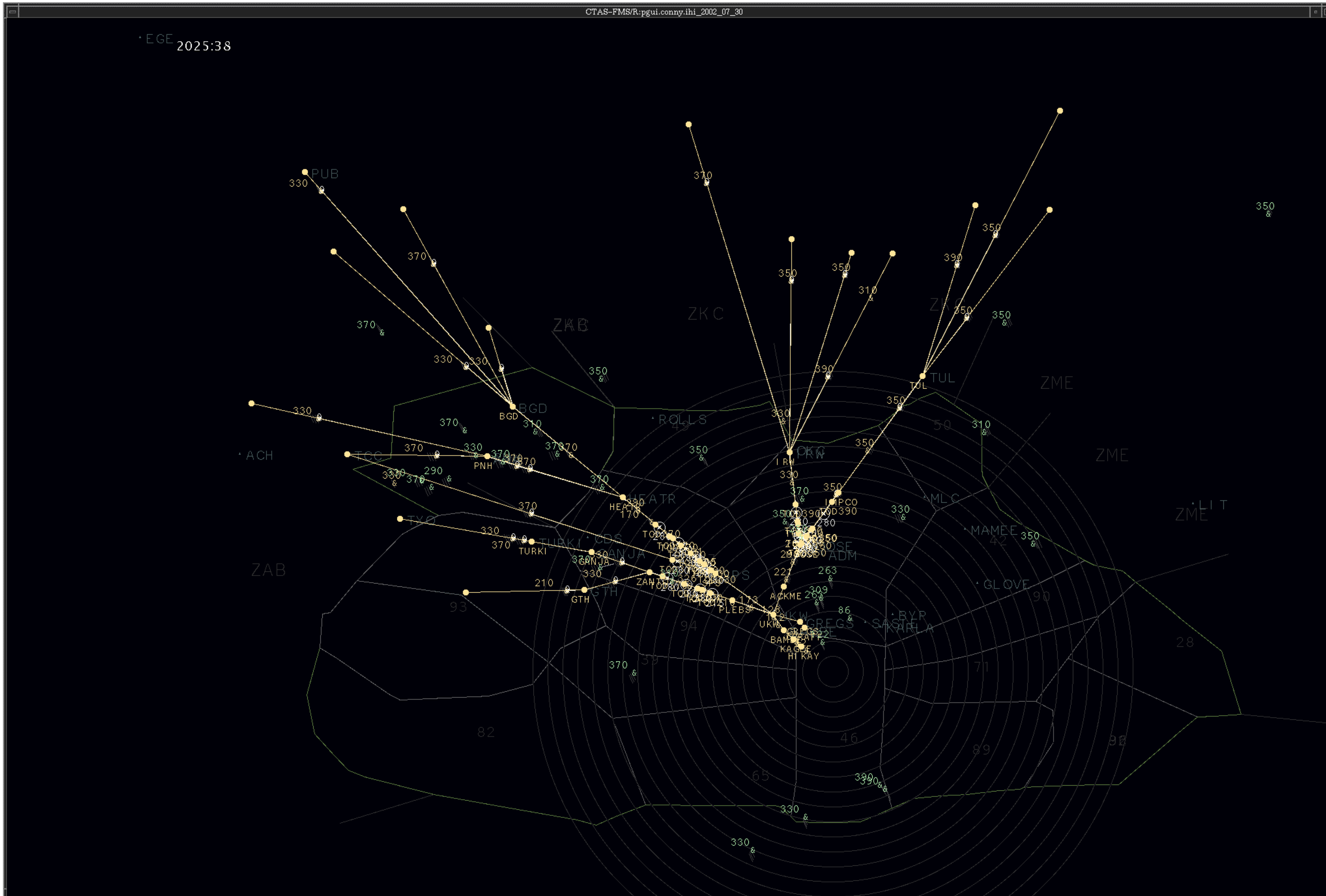
Our scenario design goals:

- Support elaboration/ iteration/ refinement of DAG tools and procedures
- Enable comparison of different operational concepts for managing en route & arrival traffic
- Get controller and pilot feedback about DAG concepts
- Assess benfits, operational viability of DAG concepts

Ames' DAG-TM airspace & traffic flows



CFI_94 scenario snapshot: all targets & arrival routes



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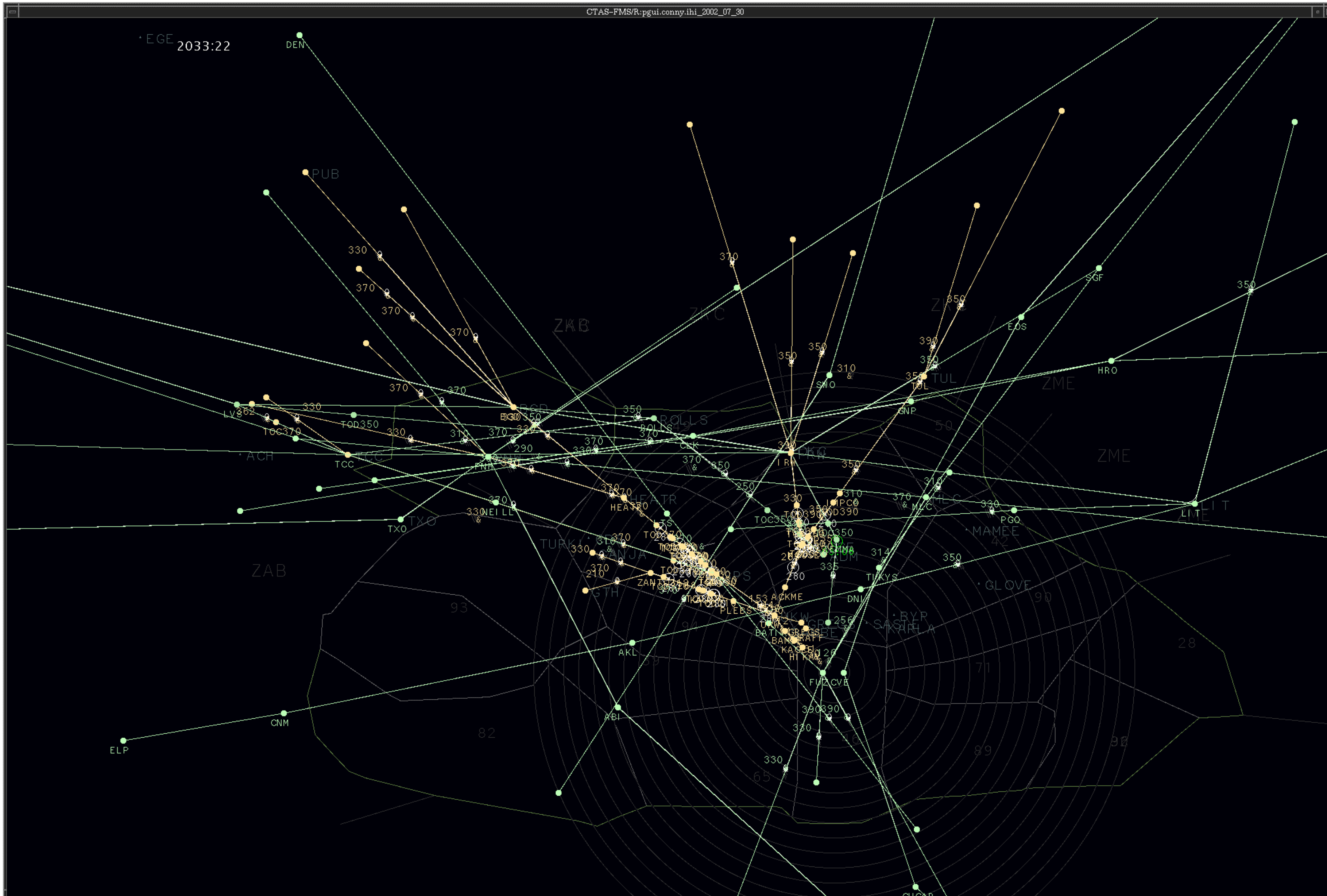
CFI_94 scenario snapshot: all targets & routes shown



Scenario description

- *One basic traffic scenario:*
  - Approximately 75 minutes long, moderately heavy arrival rush, with traffic merging at ZFW's northwest cornerpost (Bambe).
  - Around 45 arrival aircraft, majority from northwest. A secondary flow from the north/northeast merges in at meter fix. DFW arrivals (initially) on UKW7 STAR.
  - Other traffic includes roughly 6-8 departures, 30 overflights, 3 DAL arrivals from northwest, 2-6 DFW arrivals to northeast cornerpost
- *Run-to-run variations:*
  - Some between-run variations in aircraft ID, start time and location
  - Scenarios are repeated in 2-3 different operational conditions:
    - CE6/11 runs use all the DAG-TM automation tools, procedures and interface, with CDTI-equipped aircraft under ATC control
    - CE5/11 runs use the same air and ground tools as CE 6/11, but CDTI-equipped aircraft are self-separating (autonomous)
    - Baseline runs approximate today's operations with TMA time-based metering
- *Some scenario variations:*
  - TMA meter fix miles-in-trail constraint is manipulated to vary delay
  - Some runs have increased flow from north, and can include aircraft re-route to/from northeast cornerpost
  - Some runs included automatic uplink of meter fix STA or RTA
  - Some runs included an arrival planner, or TMC position

Situations or problems included in DAG 2002 scenarios

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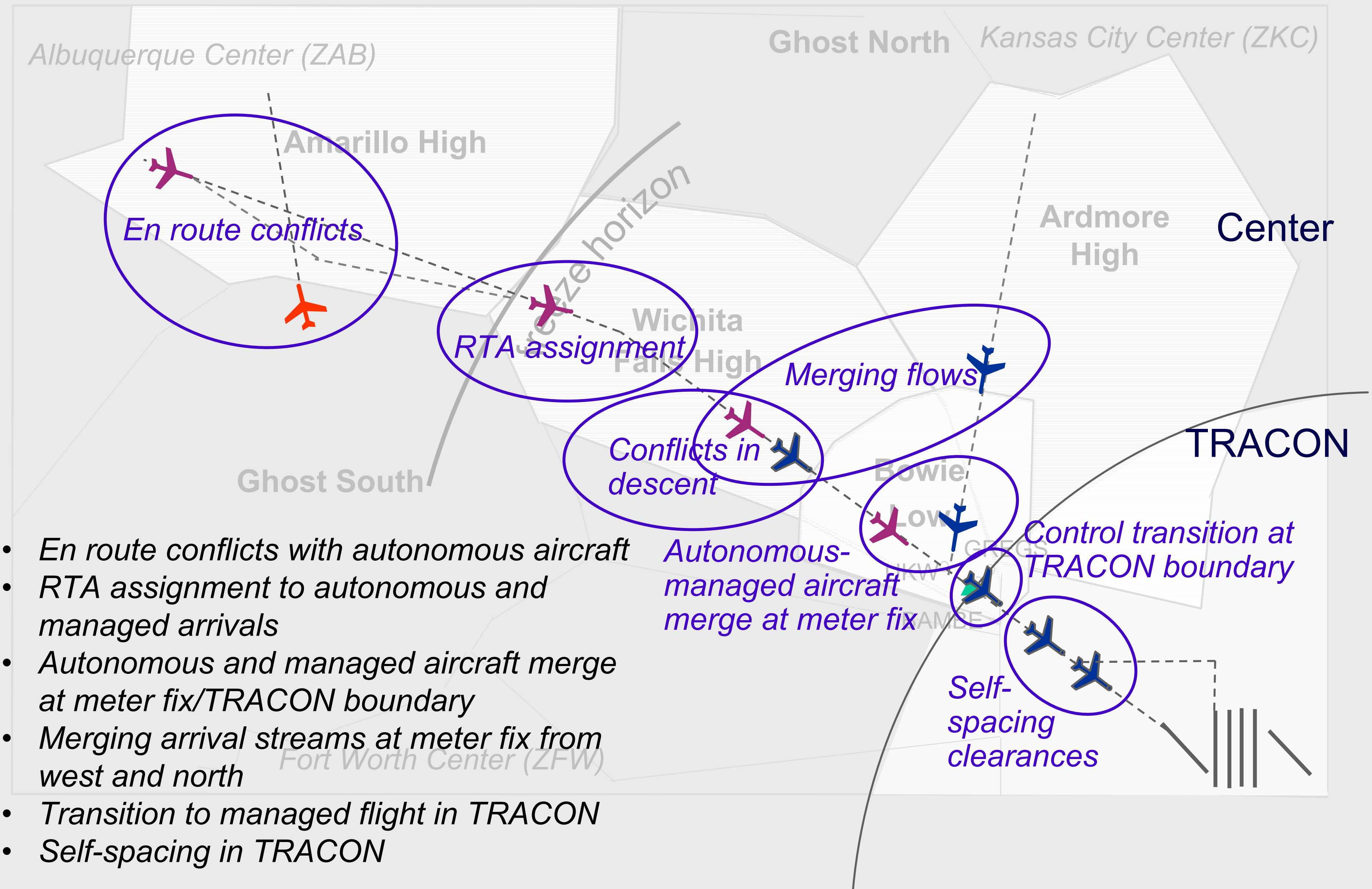
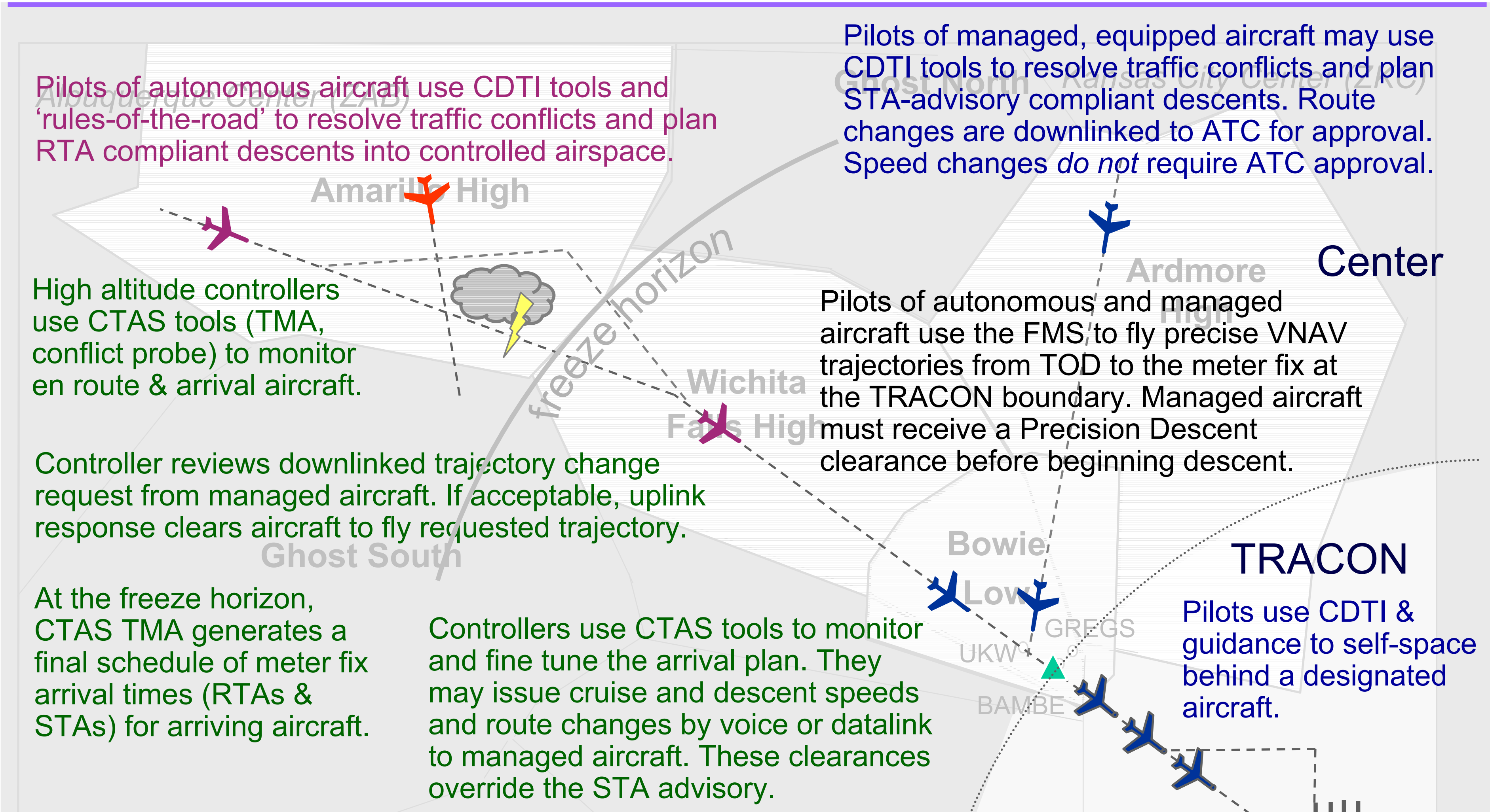


- En route conflicts with autonomous aircraft
- RTA assignment to autonomous and managed arrivals
- Autonomous and managed aircraft merge at meter fix/TRACON boundary
- Merging arrival streams at meter fix from west and north
- Transition to managed flight in TRACON
- Self-spacing in TRACON

Basic scenario - Concept Elements 5, 6 & 11



Automatic Information Exchange:

- *Broadcast aircraft ADS state.*
- *Broadcast FMS trajectory whenever it changes.*
- *Uplink descent winds to synchronize trajectory computations.*
- *Uplink TMA meter fix times (RTAs or STAs) and speed advisories.*

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New situations / problems for DAG 2003-4 scenarios

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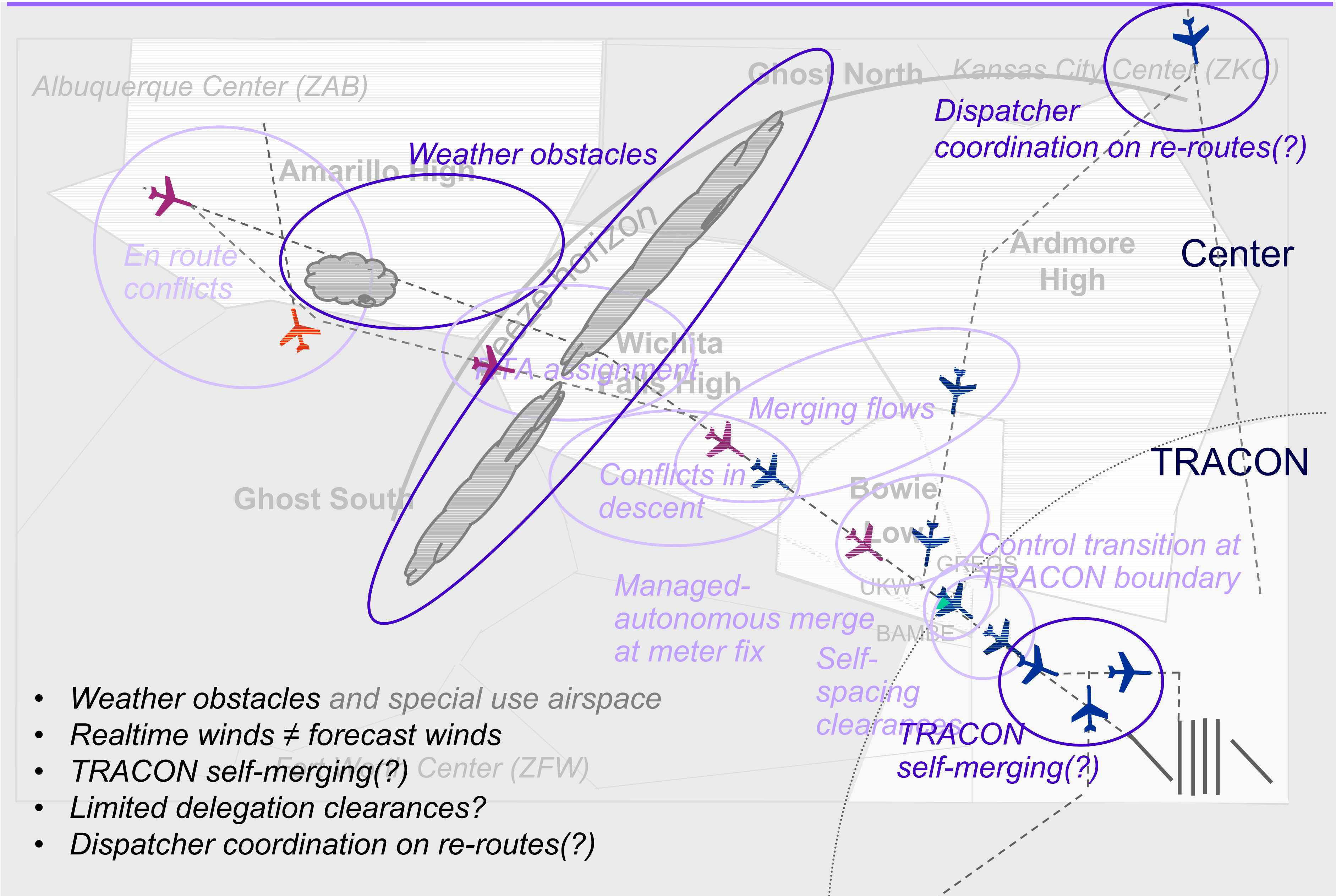
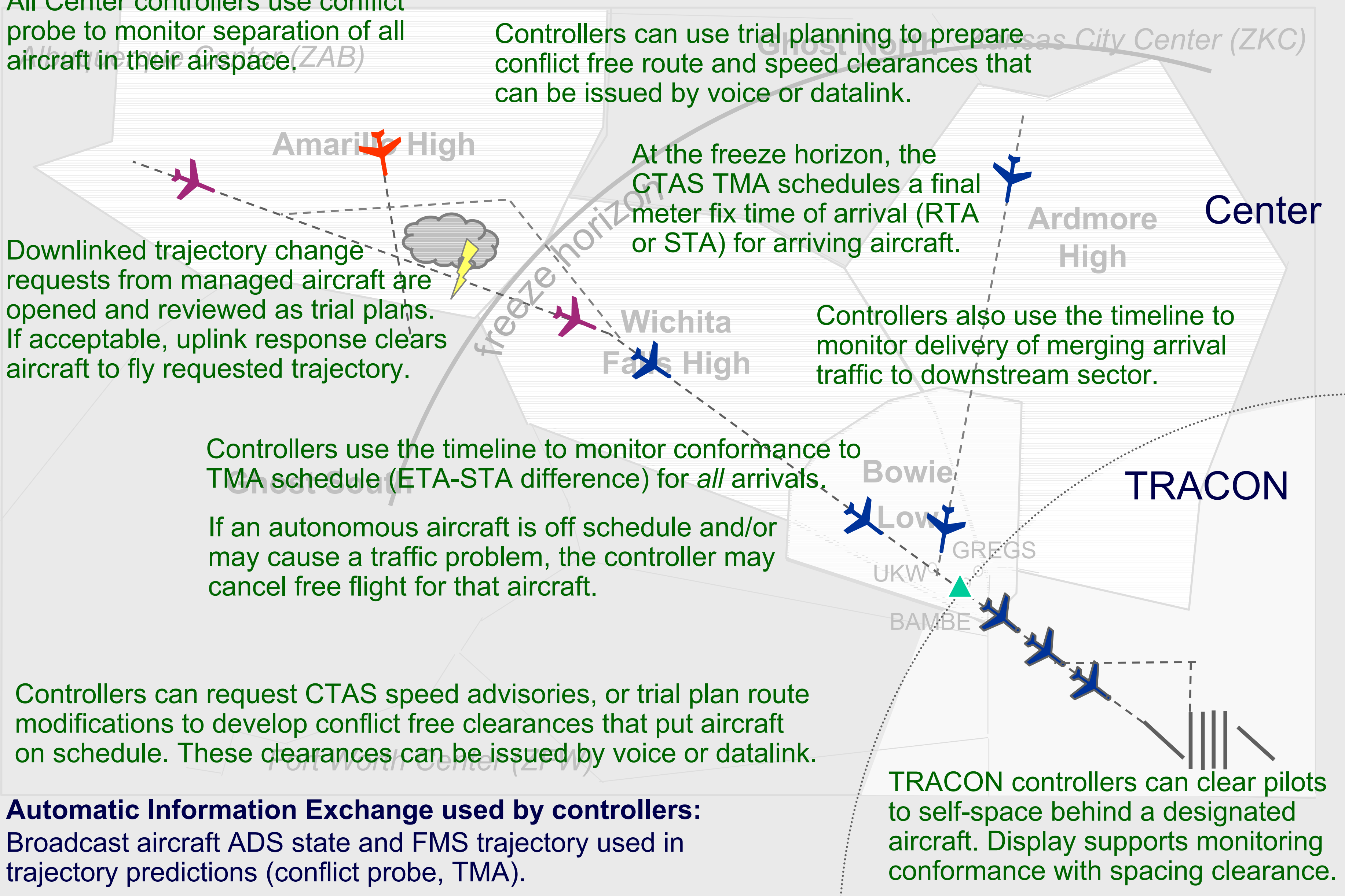


- *Weather obstacles and special use airspace*
- *Realtime winds ≠ forecast winds*
- *TRACON self-merging(?)*
- *Limited delegation clearances?*
- *Dispatcher coordination on re-routes(?)*

Basic scenario – Controller's point-of-view



All Center controllers use conflict probe to monitor separation of all aircraft in their airspace.

Controllers can use trial planning to prepare conflict free route and speed clearances that can be issued by voice or datalink.

At the freeze horizon, the CTAS TMA schedules a final meter fix time of arrival (RTA or STA) for arriving aircraft.

Downlinked trajectory change requests from managed aircraft are opened and reviewed as trial plans. If acceptable, uplink response clears aircraft to fly requested trajectory.

Controllers also use the timeline to monitor delivery of merging arrival traffic to downstream sector.

Controllers use the timeline to monitor conformance to TMA schedule (ETA-STA difference) for *all* arrivals.

If an autonomous aircraft is off schedule and/or may cause a traffic problem, the controller may cancel free flight for that aircraft.

Controllers can request CTAS speed advisories, or trial plan route modifications to develop conflict free clearances that put aircraft on schedule. These clearances can be issued by voice or datalink.

TRACON controllers can clear pilots to self-space behind a designated aircraft. Display supports monitoring conformance with spacing clearance.

Automatic Information Exchange used by controllers:
Broadcast aircraft ADS state and FMS trajectory used in trajectory predictions (conflict probe, TMA).

Basic scenario – Pilot's point-of-view

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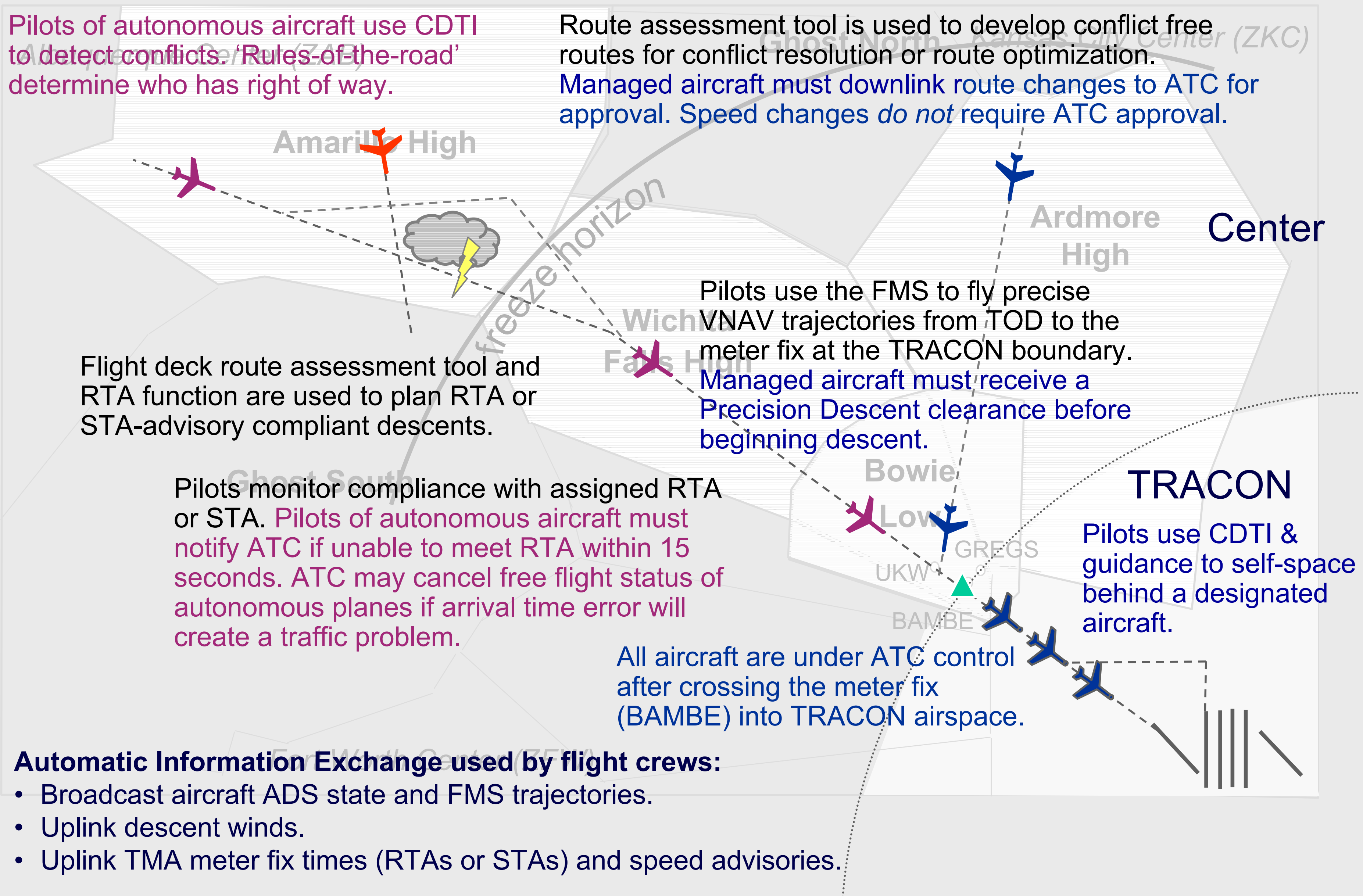

Pilots of autonomous aircraft use CDTI to detect conflicts. 'Rules-of-the-road' determine who has right of way.

Route assessment tool is used to develop conflict free routes for conflict resolution or route optimization. Managed aircraft must downlink route changes to ATC for approval. Speed changes *do not* require ATC approval.

Pilots use the FMS to fly precise VNAV trajectories from TOD to the meter fix at the TRACON boundary. Managed aircraft must receive a Precision Descent clearance before beginning descent.

Flight deck route assessment tool and RTA function are used to plan RTA or STA-advisory compliant descents.

Pilots monitor compliance with assigned RTA or STA. Pilots of autonomous aircraft must notify ATC if unable to meet RTA within 15 seconds. ATC may cancel free flight status of autonomous planes if arrival time error will create a traffic problem.

Pilots use CDTI & guidance to self-space behind a designated aircraft.

All aircraft are under ATC control after crossing the meter fix (BAMBE) into TRACON airspace.

Automatic Information Exchange used by flight crews:

- Broadcast aircraft ADS state and FMS trajectories.
- Uplink descent winds.
- Uplink TMA meter fix times (RTAs or STAs) and speed advisories.

Approach to demos and experiments

- *Evaluate and compare different operational concepts*
  - CE-6: a “trajectory oriented” concept with new air & ground tools and procedures
  - CE-5: CE-6 operations, but with some autonomous flights in traffic mix
  - CE-11: Self-spacing operations in TRACON airspace
  - Baseline: a “sector oriented” concept using TMA, similar to today’s operations
- *Airspace encompasses pure en route to runway threshold in TRACON*
- *“Ownship” aircraft start in cruise and fly ~200-300nm to runway threshold*
- *Simulation particants include:*
  - *4-5 FPL controllers at CTAS Center and TRACON PGUI stations*
  - *2-8 commercial pilots at CDTI equipped PC-Planes or ACFS*
  - *2-3 “cohort” controllers at CTAS stations*
  - *5-7 “pseudo-pilots” at MACS pseudo-aircraft stations*
- *Demos:*
  - 2-3 days
  - 1 or 2 focused topics
  - Limited training
  - Several simulation runs
  - Discussion
- *Experiments:*
  - 2 weeks (1 week training, 1 week data collection)
  - Compare CE-6 to CE-5 and/or baseline operations
  - Compare CE-11 to baseline operations
  - Repeat scenarios under different operational concepts
  - Record subjective & quantitative data
  - Discussions…

Flight deck and ATC tools & procedures (DAG, Sept. 2002)

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Flight Deck Tools & Procedures	Baseline	CE 6 & 11 Trajectory Negotiation		CE 5 & 11 Free Maneuvering	
	All Aircraft	*Unequipped*	*Equipped*	*Unequipped*	*Equipped*
Flight Management System (FMS)	x	x	x	x	x
Cockpit display of traffic information (CDTI)	x	x	x	x	x
ADS-B	x	x	x	x	x
Conflict detection & resolution capability (CD&R)			x		x
Route planning			x		x
Controller-pilot data link (CPDLC)		x	x	x	x
Precision Descent Procedures		x	x	x	x
Self-spacing capability		x	x	x	x
Rules of the Road					x
RTA capability		x	x	x	x

ATC Tools & Procedures	Baseline	CE 6 & 11 Trajectory	CE 5 & 11 Free Maneuvering
TMA	x	x	x
Descent Advisory		x	x
Conflict detection		x	x
Trial planning		x	x
Arrival spacing capability		x	x
Control exchange capability			x
Rules of the Road			x

Some metrics from the 2002 simulations

- *Benefits*
  - Predictability/quality of arrival flow at meter fix:
    - Arrival time accuracy* (CTAS scheduled time of arrival – actual time of arrival)
    - crossing restriction compliance (altitude, speed)
    - Meter fix spacing between aircraft (time)
  - Efficiency:
    - Flight time* (160nm arc to meter fix)
    - Travel distance* (160nm arc to meter fix)
    - Average altitude (160nm arc to meter fix)
    - Arrival delay*
  - Air/ground communications
    - Clearance metrics (voice and datalink)
    - Radio communications metrics
    - Controller-controller communication
- *Operational viability*
  - Safety: separation violations
  - Workload impact and redistribution
    - Controller workload
    - Pilot workload
  - Acceptability to pilots and controllers
  - Tool usability

**Derived from or related to FFP1 TMA Metrics*

Summary

- The simulation airspace is large enough, and varied enough to incorporate a variety of relevant situations for DAG-TM.
- Current scenarios can be adapted for new DAG-TM situations (weather, merging, etc.).
- Traffic count & arrival flow are adequate to assess benefits.
- Metrics support assessment of CE feasability & benefits.
- Simulation runs stimulate discussions with pilots and controllers about air-ground tools, procedures & concepts.

END

Airspace Operations Laboratory Layout

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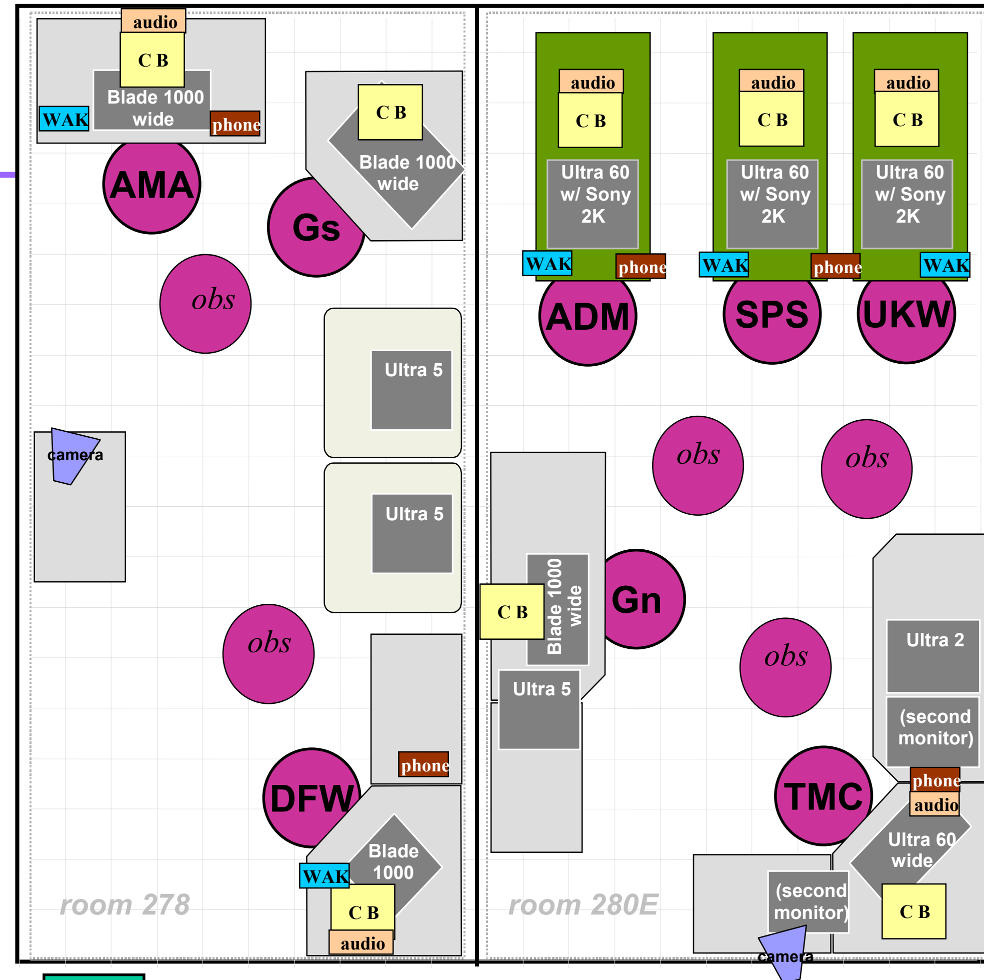

Controller Positions:

- **AMA:** Amarillo High (ZAB)
- **ADM**: Ardmore High (ZFW)
- **SPS**: Wichita Falls High (ZFW)
- **UKW**: Bowie Low (ZFW)
- **TMC/Arrival Planner** (ZFW)

Confederate Positions:

- **Ghost S** (ZAB, ZFW)
- **Ghost N** (ZFW, ZKC, ZME)
- **DFW TRACON**

WAK — Workload assessment keyboard

audio — Audio recording input

phone — Speaker phone (for land-line comm.)

camera — Camera

Comm Box — Comm box (air-ground voice comm.)

Recorded data

- Aircraft state information
  - Position, speed, altitude, flight plan
- MACS operator inputs
- Controller PGUI operations
  - Clearance entries, datalink messages, handoffs, advisory access, trial planning…
- CTAS content
  - conflict predictions, STA & ETA from TMA schedule
- ATWIT workload
- Questionnaires
- Observer notes
- Audio recording (air-ground communications)
- Video recording (ATC room overview)

Study Objectives for CFI'02 Simulations

Compare a near-term "sector-oriented" approach to arrival flow management to a candidate far-term "trajectory-oriented" approach.

- ***Sector-oriented – ETMA (Enhanced TMA):***
  - TMU has CTAS TMA (Traffic Management Advisor) tool
  - "current day" time-based arrival metering to meet TMA-generated schedule
  - some added TMA support on sector positions
- ***Trajectory-oriented – CFI (CTAS/FMS Integration):***
  - TMU has TMA and arrival planning and coordination tools
  - FMS trajectory planning used to meet TMA schedule
  - additional controller automation: conflict probe, color-coded displays, datalink of clearances, interactive timeline on sector controller's display, speed advisories to meet TMA scheduled arrival times

Between conditions comparison to determine differences in:

- ***Benefits:***

  Arrival rate, delay, transit time, fuel consumption, flexibility, communications, workload.
- ***Operational viability & safety:***

  operational errors, tolerance of plan to disturbances, workload, controller acceptability, controller situation awareness, communications.

Summary of ETMA & CFI Conditions (CFI'02)

Both conditions:

- 50% ADS equipage
- Toolbar
- Shortcut window
- Ground-ground voice comm
- TGUI (TMA interface) for TMU
- Center overview PGUI
- Standard arrivals

ETMA condition only:

- Sequence list
- Delay information near aircraft target symbol (color coded)

CFI condition only:

- 50% CPDLC equipped
- Precision Descent procedure
- Timeline
- Conflict list
- Trial planning
- Speed advisories
- Trajectory preview ('lookahead')
- Expandable flight data block
- Color-coded arrivals & non-arrivals
- Graphical trial plan coordination
- Arrival planning PGUI